Before the
Federal Communications Commission
Washington, DC 20054

In the Matter of

Inquiry Concerning the Deployment of) Advanced Telecommunications) Capability to All Americans in a Reasonable) and Timely Fashion, and Possible Steps) to Accelerate Such Deployment) Pursuant to Section 706 of the) Telecommunications Act of 1996)	GN Docket No. 04-54

Comments of Pulse~LINK, Inc.

1. General Remarks

Pulse~LINK thanks the FCC for this opportunity to provide remarks concerning Advanced Telecommunications Capabilities and ways to accelerate their deployment to all Americans. These comments are directed to new developments in high-speed "last mile" applications. Additionally, comments are directed to new in home technologies and architectures that can take advantage of the new developments. Essentially, there are three wired media interfaces into most homes, a coaxial connection, a powerline connection, and phone line connections. Traditionally, most of wired media have been utilized to provide services into the home over limited bandwidths. The phone lines traditionally carried voice, the power lines were limited to electrical current for the home, and the coaxial connection was used for distribution of content from the cable head-end into the home. Recent developments such as cable modems, DSL and its variants, as well as broadband powerline technologies have changed the way data is communicated into and out of the home.

Wired media are generally considered to be band limited channels since the signals supported by most wired media are substantially attenuated at higher frequencies particularly when compared to wireless media. Due to this attenuation, as signals travel greater distances across wired media the bandwidth supported by the media decreases with distance. Many technologies take advantage of the wired media in a home, but typically utilize only a fraction of the bandwidth available to them over the media. For example, voice on a telephone line actually consumes less than 10 KHz of bandwidth even though it has been demonstrated that telephone lines are capable of supporting tens of MHz of bandwidth. Power lines supply AC power at 60 Hertz but have demonstrated similar bandwidths to phone lines in the tens of MHz. Ultra-Wideband is well suited for wired media applications because of its ability to spread its signal energy across the entire available bandwidth of the specific wired media it is being applied to, thereby utilizing the entire available spectrum of wired media.

2. Ultra-Wideband Communications in the Last-Mile

In the Third Report the FCC described in detail several "last-mile" technologies including (1.) cable modem service; (2) digital subscriber line (DSL); (3) other local exchange carrier provided wireline services; (4) terrestrial fixed wireless service; and (5) satellite service.[1] In the Notice of Inquiry the Commission specifically sought comment on new developments in this area. The solicitation for comment addressed technologies such as Wi-Fi, WI-Max, and broadband over powerline.[2] Pulse~LINK is currently developing and in the near term may begin initial deployment of a system involving Ultra-Wideband (UWB) in the last mile.

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[1] See Notice of Inquiry, FCC 04-55, Page 9.
[2] Id.

a. Ultra-Wideband Communications

UWB communications is a fundamental departure from other conventional forms of communications. In most commercial RF communications the signal transmitted and received is a carrier wave. Data is modulated onto the carrier wave at the transmitter and sent through the air to a receiver. The receiver demodulates the data from the carrier. In most communications technologies the carrier wave is substantially continuous. In traditional UWB communications there is no carrier wave. A pulse train is generated and modulated with data. The receiver then demodulates the data from the received pulse train.

This impulse nature of UWB communications makes it difficult to classify in conventional communications terms. By communicating with pulses of extremely short duration, the transmitted power may be spread across very wide bandwidths. The current UWB regulations require transmission powers that are within the unintentional emission limit specified in 47 CFR 15. For wireless communications, the frequency band authorized for UWB communications is from 3.1 to 10.6 GHz. According to FCC regulations, to be classified as UWB, the transmitted signal must occupy 20% fractional bandwidth or at least 500 MHz.[3] Because of the extremely low power limitations and very wide bandwidth, UWB has been commonly referred to as a frequency underlay technique. A UWB signal may be present at the same frequencies as other conventional "narrowband" services and not produce interference since the UWB signal power in the band of the narrowband service is typically considered within the noise floor.

[3] 2nd Report and Order, In the matter of Ultra-Wideband Communications, FCC Docket 98-153.

The Institute of Electrical and Electronic Engineers (IEEE) is currently working on standards for UWB technology in the 802.15.3a working group. Despite not having a final standard agreed upon, a number of companies are developing communications devices utilizing UWB technologies. While most companies in the UWB arena are pursuing Wireless Personal Area Networks (WPAN) devices, and a few looking into Wireless Local Area Network (WLAN) devices using UWB, Pulse~LINK is additionally developing UWB solutions for wireline media. The WPAN solutions may be difficult to classify as "last mile" solutions since the target range for these devices is 10 meters. Additionally, the WLAN solutions are targeting 100 meters. UWB over wired media can provide significant bandwidth into and out of the home over substantial distances.

b. UWB over CATV architectures

UWB is not just for wireless communications. On June 25th, 2002 Pulse~LINK announced its "wired media" initiatives.[4] Historically, wireline communications techniques have migrated to the wireless arena. For UWB the opposite is true. Marconi's first transmissions with the "spark gap" transmitter can be thought of as the first UWB radio transmissions. The carrier of Marconi's transmitter was not the frequency based carriers of most modern telecommunications rather they were pulses similar to modern UWB communications. UWB as applied to Hybrid Fiber Coax (HFC) television distribution systems shows promise to increase the bandwidth capacity of the downstream system by as much as 1.2 Gbps, without degradation to the current content of the system. In the upstream UWB has the potential to increase

[4] http://www.pulselink.net/pr-june25-2002.html

bandwidth by as much as 480 Mbps. This system is in the early stages of development at Pulse~LINK but shows great promise.

Cable television is made possible by the technology of coaxial cable. Rigid coaxial cable has a solid aluminum outer tube and a center conductor of copper-clad aluminum. Flexible coaxial cable's outer conductor is a combination of metal foil and braided wire, with a copper-clad, steel center conductor. The characteristic impedance of the coaxial cable used in cable television is 75 ohms. The well-known principles of transmission line theory apply fully to cable television technology. Modern Cable television distribution networks, HFC networks, employ fiber links from the providers head-end out to nodes located within the neighborhoods serviced. From the node to the customers premises are still wired with coaxial cable. The bandwidth limitation of these systems is the coaxial portion of the system.

The most important characteristic of coaxial cable is its ability to transport in a shielded media spectral content over a broad range of frequencies with relatively low loss (DC to 3GHz+). In essence a separate frequency spectrum of its own, shielded from the outside world. This means that a television receiver connected to a cable signal will behave in a similar manner than if it were connected to an antenna. Since the cable spectrum is tightly sealed inside an aluminum environment (the coax cable), a properly installed and maintained cable system can use frequencies assigned for other purposes in the over-the-air environment. This usage takes place without causing interference to these "Over-the Air" applications that might otherwise co-exist in the same frequency domain. Due to the "Shielded" nature of these signals within the coax cable new spectrum separate from the "Over-the- Air" spectrum is "created" inside the cable. In some cable systems, dual cables bring two of these sealed spectra into the subscriber's home, with each cable containing different signals.

Pulse Link's Ultra Wideband cable technologies increase bandwidth by super-imposing an UWB signal into the existing data signal as illustrated in FIG. 1 and subsequent recovery of the UWB signal at the set-top box or subscriber gateway. Hence Pulse~LINK technology offers significant bandwidth increases with no modification to the existing network infrastructure.

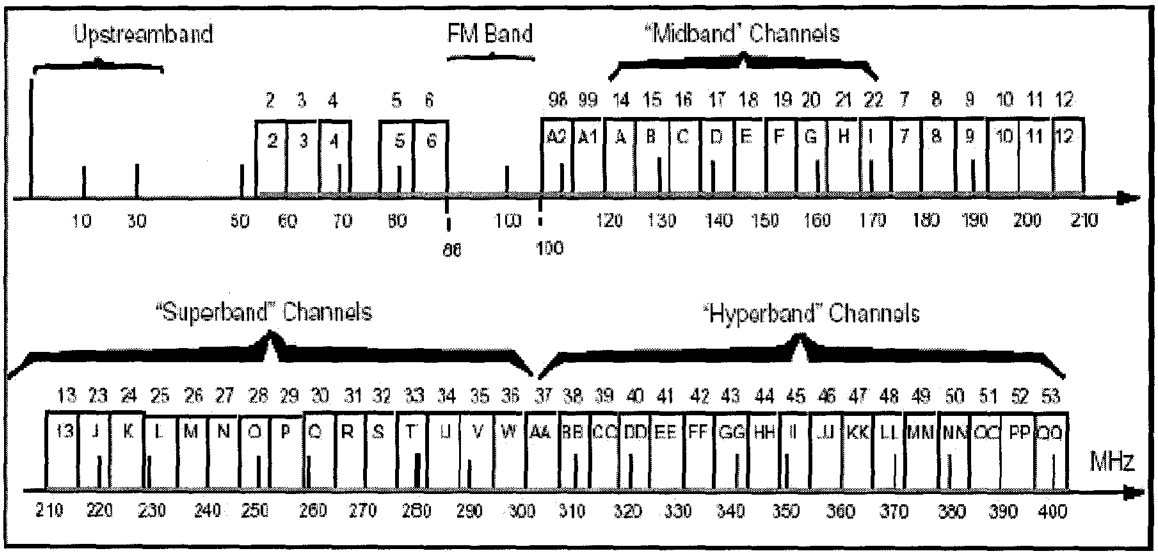

FIG. 1 A Frequency Plan with a UWB signal (green)

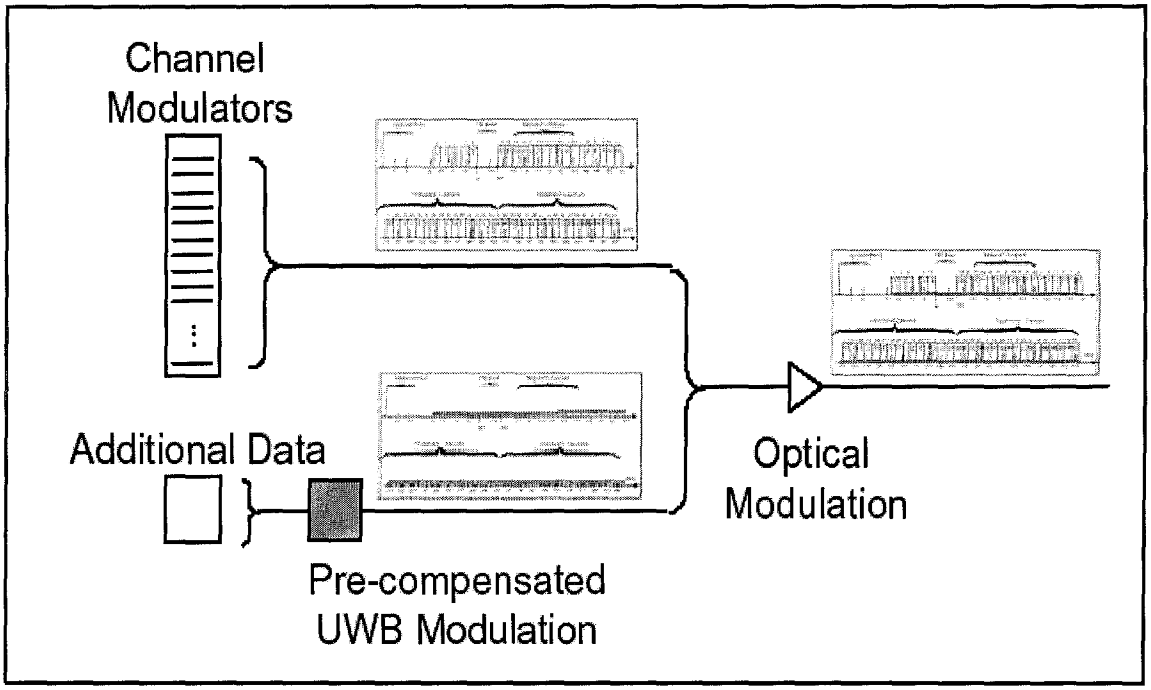

FIG. 2 UWB Communications over HFS Distribution Systems

Pulse~LINK's UWB solution for CATV/HFC systems is illustrated in FIG. 2. The normal content is modulated into the standard frequency plan employed by the plant operators. Additional data is modulated onto a pre-compensated UWB signal and overlaid onto the signal to be transmitted. The combined signal is sent to the HFC distribution through the normal optical modulator. In the customer's premises, the UWB signal content may be extracted by a UWB enabled set top box or home gateway. Pulse~LINK's unique UWB technology is capable of substantially increasing the capacity of most cable systems bearing NTSC, SECAM or PAL signals with NO MODIFICATION to existing infrastructure allowing additional data rates into the 100's of Mega Bits. In addition, data rates for the upstream channel can be increased substantially as well enabling bi-directional communication though existing CATV/HFC networks without interfering with existing channel content.

c. UWB over Powerline Systems:

"The idea of using the alternating current (AC) power lines to carry information to a variety of devices is not new. A number of devices or systems already use carrier current techniques to couple radio frequency (RF) energy to the AC electrical wiring for purposes of communication. For example, AM radio systems on some school campuses employ carrier current technology;[5] many devices intended for the home, such as intercom systems and remote controls for electrical appliances and lamps also utilize carrier current technology;[6] and for many years, electric utilities have been using carrier current technology to monitor and control the electrical power grid. More recently, these systems have been used to convey information in digital form, providing communications at relatively slow transmission speeds on carrier frequencies below 2 MHz. All such devices are subject to our existing Part 15 rules for low-power, unlicensed equipment operating on a non-interference basis.[7]"[8]

A number of technologies are currently being investigated for power line communications. It is important to note that the current regulatory definition of UWB is a signal that occupies either a 20% fractional bandwidth or a signal that is at least 500 MHz wide. In wired media applications, 20% fractional bandwidth may be significantly lower than 500 MHz. For example, in a Hybrid Fiber Coax system a signal may have a center frequency of 400 MHz.

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5 Campus radio systems have been operating for over fifty years in the United States at many universities as unlicensed broadcast radio stations in the AM Broadcast band. Initially, the receiver and signal source were attached to the same electric power line. With the advent of the transistor radio, the receiver is still able to pick-up enough signal for adequate reception when placed next to the electric power line in a dormitory or other locations on the electric power lines. *See* 47 C.F.R. § 15.221.

6 *See e.g.*, X-10 products for home automation at <http://www.X10.com>, and products conforming to ANSI/EIA-600.31-97 *Power Line Physical Layer and Medium Specification* (CEBus Standard).

7 *See* 47 C.F.R. §§ 15.3(f) & (t), 15.5, 15.31(d), (f), (g) & (h), 15.33(b)(2), 15.107(a)-(c), 15.109(a), (b), (e) & (g), 15.113, 15.201(a), 15.207(c), 15.209(a) and 15.221.

8 Notice Of Inquiry, In the Matter of Inquiry Regarding Carrier Current Systems, including Broadband over Power Line Systems FCC Docket 03-104,

To meet the definition of UWB this signal need only occupy 80 MHz (20% fractional bandwidth). In a powerline communications system a signal centered at 20 MHz need only occupy 4 MHz to be considered UWB. This is a substantial departure from wireless UWB where signals can occupy GHz of spectrum, or at a minimum 500 MHz.

Generally, there are three modes of noise most common: Gaussian noise, low voltage impulsive interference, and very high voltage spikes. Of these three, the low voltage impulsive interference tends to be the predominant cause of data transmission errors. Therefore, data transmission may be reliably accomplished though power lines even in the presence of Gaussian noise. As for high voltage spikes, they are relatively infrequent and can potentially cause data errors, but with error detection/retransmission (ACK/NACK) being commonly recognized as the best method of recovering the lost information. Furthermore, these characteristics may vary significantly as the electrical power load conditions on the line vary. For example, such electrical load variation may be caused by power draw from virtually any type of electrical device, such as industrial machines, electric motors in household and commercial appliances, light dimmer circuits, heaters, battery chargers, computers, video monitors, audio equipment, and any other device that requires electricity to operate.

Typically, different types of data transmission formats are susceptible to different types of attenuation and distortion. Narrowband transmission formats such as frequency shift keying (FSK) or amplitude shift keying (ASK) are somewhat immune to frequency dependent attenuation, and thus may suffer little or no distortion. However, the entire narrowband signal may fall into an attenuation null and be severely attenuated. Wideband transmission formats such as spread spectrum are less susceptible to the signal degradation caused by narrowband attenuation null. However, due to the wider bandwidth associated with a spread spectrum signal, the spread spectrum signal experiences more distortion due to frequency dependent attenuation. Thus, a conventional narrowband signaling format is susceptible to attenuation while a conventional wideband signaling format is more susceptible to distortion.

Another technique employed in Power Line Communications (PLC) is the use of Orthogonal Frequency Division Multiplexing (OFDM). OFDM is a method of digital modulation in which a data stream is split into multiple narrow band channels of contiguous but different frequencies. The standard approach to OFDM is to use the same data allocation to all frequencies, similar to the IEEE 802.11a standard. However, while possible this type of data allocation scheme is undesirable in power line media since some frequencies are severely attenuated. A conventional fix to this problem is to allow the transmitter and receiver to adapt to the characteristics of the channel disabling those OFDM carriers where significant attenuation nulls exist. But this approach dramatically increases the complexity and cost while simultaneously decreasing the available bandwidth.

Yet another method for transmitting data through power lines is frequency division multiplexing (FDM) and time division multiplexing (TDM). One feature of the present invention is that ultra-wideband (UWB) pulses, or signals can co-exist with either the OFDM or the FDM/TDM approach, thereby increasing the bandwidth of the communication system.

UWB shows great promise for broadband communications over in-home electrical power distribution. Coupling UWB pulse signals to the local in-home power lines, Pulse~LINK has been able to achieve simultaneous symmetrical two-way data rates of 62.5 Mbps in each direction and asymmetrical 100+ Mbps in one direction. Pulse-Link has demonstrated UWB power line communication with streaming video in both uni-directional and bi-directional modes. It is important to note that emissions from broadband signals over power lines have been classified in two ways. "A carrier current system can be designed such that the signals are received by conduction directly from connection to the electric power line (unintentional radiator), or the signals are received over-the-air, due to radiation of the radio frequency signals from the power line (intentional radiator).[9]" The emissions from Pulse~LINK's over power line UWB solution are "unintentional" since the UWB enabled devices are transmitting and receiving signals by conduction directly to and from the power line.

d. UWB over Twisted Pair Wire Media:

UWB signals have additionally been successfully applied to twisted pair media such as phone lines. The bandwidth of this media type is slightly higher but comparable to UWB over power line. UWB over Twisted Pair shares the same characteristics of "unintentional" emission as the powerline since the transmission and reception are directly from the twisted pair line not from "over-the-air". Twisted pair media are made in a number of configurations some shielded and others not shielded. Additionally, twisted pair media are classified by how tightly the individual pair is twisted. Some twisted pair media support higher bandwidths than others. A UWB signal can be made to occupy the entire available bandwidth of twisted pair media and provide additional capacity to the network.

3. Pulse~LINK's Vision for the Digital Millennium:

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9 *See* 47 C.F.R. §§ 15.3(z) and 15.3(o), respectively.

Pulse~LINK's vision for broadband services to the American public include an integrated UWB solution. It provides ubiquitous connectivity of all networked consumer electronics and appliances throughout entire home. Originating at the CATV/HFC head end, additional content can be provided into the customer's premises. The additional content is modulated onto a UWB signal that is then superimposed onto the conventional frequency plan for CATV distribution. At the customers premises the signal can be received by a UWB enabled home gateway. This gateway is additionally enabled to distribute the content throughout the home via the installed power lines, phone lines or wirelessly. Devices requesting content make the request through any UWB enabled connected media from the home gateway. The gateway can then make the request from the CATV/HFC head-end via a UWB signal in the upstream. This Bridged Ultra-WideBand Architecture (BUWBA) allows a UWB enabled device in the home or customer premises to be serviced directly from the head-end.

This vision allows for a number of unique advantages. The UWB enabled home gateway may determine over which media to route the content to the requesting device based on network traffic, current wireline noise conditions, priority and quality of service requirements to name a few. Additionally, since the individual requesting device has a unique identifier, such as a MAC address or device ID the CATV head-end is capable of delivering that digital content in an end-to-end secure delivery system. This secure system is capable of providing Digital Rights Management (DRM) across the entire system from the CATV headend directly into the consumer's home and to a specific device. Pulse~LINK is rapidly moving toward realizing this vision. The vision includes an integrated chipset that supports communications across wireless, and wireline media. Additionally, since Pulse~LINK's chipset, currently under development, has a wide variety of software and firmware re-programmability, and interfaces to a wide range of media. This ability allows Pulse~LINK to provide a seamless user experience to the consumer who will not have to worry about how to route digital data to which media type or bandwidth requirements or whether they have the latest version. UWB Wireless LAN, UWB CATV, UWB Powerline, and UWB twisted pair communications can all be supported from a single chipset. A true software defined cognitive radio for both wired and wireless Medias. Pulse~LINK has working discrete prototypes and is expecting tape-out of a fully functional test chip by years end.

Respectfully Submitted
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